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ABSTRACT

Four variables have been identified by research as having a powerful influence on teachers' teaching practices and student learning. These are: (1) content coverage; (2) content exposure; (3) content emphasis; and (4) quality of instructional delivery. These four variables are important to the investigation of students' opportunity to learn science in U.S. classrooms. Current instructional practices systematically place certain groups of students at a disadvantage, and the goal of scientific literacy for all students cannot be met. Two models of learning, cooperative learning and constructivism, have been effective in helping poor and minority students to achieve. While there is an abundance of information about improving students' opportunity to learn, there is still a disconnection between research knowledge on improving academic achievement through addressing opportunity to learn and the implementation of knowledge in classrooms. Connecting this knowledge and practice is enhanced by the realization that teacher education makes a difference in producing the environment conducive for learning. In addition, teacher collaboration brings support for teachers to try new approaches. Teachers who are working in communities of professionals sustain change in classrooms. It is also apparent that teaching and learning must include teachers who are learning. Teacher learning begins with preservice teacher education, which must include courses in cognitive psychology, developmental psychology, learning theory and pedagogy, and professional ethics. Teacher inservice education is also important. Educators must use the information provided by educational research. Science standards are important to the process of science education reform, but these standards must encompass expectations for teachers to upgrade their content knowledge and teaching skills through preservice and inservice education. (Contains 14 references.) (SLD)

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Laboratory for Student Success

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Opportunity to Learn Science--- Connecting Research Knowledge to Classroom Practices

Floraline I. Stevens

Background

Opportunity to learn is a conceptual framework developed from information obtained from a series of international and national research studies and survey information from 91 public school district directors of research (Stevens, 1993). These studies identified four variables that have a powerful influence on teachers' teaching practices and student learning. The emphasis is on what teachers do in their classrooms when they are teaching students and whether or not they grant students sufficient access to information and resources to enable them to learn the curriculum for their age and grade level.

This concept is in contrast to those educators, researchers and policy-makers who often attribute the lack of students' academic achievement to the environment outside of the school -- to society's negative impact on minority and poor students. However, those persons who attribute minority and poor students' low achievement solely to society's ills tend to dismiss the very important influences of schools and teachers in student learning. Thus, the four opportunity to learn variables are tied to the providers of instruction ---teachers and school principals, not to the students. The variables are: (1) content coverage; (2) content exposure; (3) content emphasis; and (4) quality of instructional delivery. Short definitions of these four variables follow:

- Content Coverage -- Whether or not students cover the core curriculum and whether or not there is a match between the content of the curriculum taught and the content of the test or assessment.
- Content Exposure -- Concerns the time allotted to students to learn (time on task) and the depths of the teaching the subject.
- Content Emphasis -- Determines which topics within the curriculum teachers emphasize and which students are chosen to receive instruction in low or high order skills.
- Quality of Instructional Delivery -- Reveals how teaching practices have an impact on students' academic achievement. This means that teachers should have a cognitive command of the subject being taught and they should monitor their performance to ensure coherent

presentations of their lessons. That is, lessons should have a beginning, middle and an end.

Students' Opportunity to Learn Science

The four variables of content coverage, content exposure, content emphasis and the quality of instructional delivery are important to the investigation of students' opportunity to learn science in the classrooms of the United States. The investigation of these variables guides us to question the "popular" notion that science education is only for the few advantaged students in the United States. If high scientific literacy is important for the general population to be able to process information effectively and for the advancement of the nation, we should concentrate our resources and our attention on the majority of students rather than upon the few advantaged students. We should motivate the so-called "average student" to take more science courses. According to Oakes and her associates (1990), this has not been the case. Students of whom teachers have low expectations in science ---- girls, students coming from low socio-economic backgrounds, African-American and Hispanic students --- are likely to get watered-down curriculum and watered-down instruction. Over the last decade nearly two-thirds of students had taken six or more semesters of mathematics in high school but only 46% of Black students and 54% of Hispanic students had done so. Oakes found that these students were called upon less often, asked lower-level questions, were given less time for answers, and were given fewer hints. These types of instructional practices systematically place certain groups of students at a disadvantage, and the goal of scientific literacy for all eludes them and us.

Current school practices bring forth issues of equity and fairness when we pre-select certain students to learn science based upon false perceptions of students' abilities and/or invalid criteria and ignore other students. Those selected students are provided with educational advantages in the form of resources, teacher attention, and recognition. These actions must not continue if we want all students to have the opportunity to learn science. In addition to the selection procedures that limit students' opportunity to learn, science education by its structural and organizational deficiencies denies large numbers of students their opportunities to learn science. This happens according to Aldridge (1992a) when elementary school children learn science by only reading about it. This happens at the junior high or middle school levels, when

students study science subjects in an inappropriate sequence and without coordination among the subjects. The sequence variations cause major differences in the science curriculum from one school and district to another. Students' opportunity to learn is greatly diminished because there is no accommodation for students who move from school to school or their families move often. In high school, when biology, chemistry and physics courses are taught as preparatory courses for college courses, only those students who plan to major in science in college are required to take all three courses. This results in few students gaining knowledge about biology, chemistry, and physics while in high school. To further exacerbate the situation, most high school students feel, and are encouraged to feel by some school-based adults, that they do not have the ability to learn science materials --- only the "able" or "college-bound" can successfully complete high school science courses. This may be true, however ability is not the culprit, it is the organization, structure and content format of the courses.

Science courses are unattractive to most high school students because they are not coordinated and are highly abstract and theoretical. In addition, not enough time is spent on each subject and the correct pedagogy is not used. Basically, students are not given a chance to understand science because the courses are essentially content-mastery organized around discrete topics with little attempt to make connections. The instructional pattern is: read the text; focus on acquisition of facts by answering factual questions of the teacher or text; and have hands-on activities that are easy or fun. These descriptions provide a few citations that show the need for reform of the science course if students' opportunity to learn science becomes a reality and not just a goal.

Science Education Reform

Setting standards is part of the process for school reform. However, standards cannot be for just the students, the providers of education should be included in the standards. Darling-Hammond (1990), underscores this when she states that the bottom line of the reform of teaching any subject, this includes science education reform, is the *interaction* between teachers and their students.

When it comes to equalizing opportunities for students to learn, knowledgeable teachers (in subject content and pedagogy) make the difference in the education of students. Mestre (1994) informs us that transmittalist instruction where students are passive receivers of knowledge is ineffective. A more effective mode of instruction is conceptual change instruction. This instruction requires that teachers possess three types of knowledge: science content, concepts already possessed by students prior to science instruction, and instructional strategies to facilitate and monitor conceptual change. Tied to these instructional changes are structural or organizational changes in science education.

Science education reform advocates: (a) Spacing learning of science subjects over several years; (b) moving learning from concrete experiences to abstract (having hands-on experiences with phenomena before science terms are defined or concepts name; (c) using a spiral approach to learning so that the same concepts, principles, laws, and theories have a familiar experience base for students while studied at successively higher levels of abstraction; and (d) allowing students to construct their own knowledge by formulating and testing hypotheses while at the same time challenging students' preconceptions (not misconceptions) through their use of scientific inquiry processes (Aldridge, 1992b).

These approaches to teaching science are already happening in several other countries. In these countries, **all** students take several years of biology, chemistry, and physics. They sequence the content and approach starting with the concrete, phenomenological, and descriptive in the early years to the semi-quantitative and empirical in the middle years, and to the more abstract in the later years. By contrast, U.S. students do not have four or five years of prior grounding in experience and applications in their science subjects, and because of this, high school science is hopelessly difficult for many students.

Implementing successful learning models in the classroom.

Two models of learning have been effective in helping poor and minority students to achieve, cooperative learning and constructivism.

- **Cooperative Learning**. Cooperative learning is a set of techniques in which students work in heterogeneous groups of four to six members and earn recognition, rewards, and

sometimes grades based on the academic performance of the group. All cooperative learning methods are not equally effective in improving academic achievement. The cooperative learning methods that produce positive academic achievement share two features: (1) group goals whereby team members work interdependently to earn teacher recognition and other forms of success; and (2) individual accountability is required, that is, group success depends on individual contributions and learning of all members (Sharan and Sharan 1989/1990; Slavin, 1987).

- **Constructivism**. Constructivism holds that we can only know what our minds trust. Therefore, knowledge is not passively received but actively constructed by the learners on a base of prior knowledge, attitudes, and values. What students learn is heavily dependent on the understanding that they bring to the task. Students come to science classes with many ideas and explanations about natural phenomena. Their ideas are experience-based and often stand in stark contrast to the scientific explanations studied in school.

The focus is to change instruction so that it helps learners to develop rich and meaningful understandings of whatever science they are studying. Students learn through the processes of predicting, hypothesizing, observing, and inferring in the service of better explanations of natural phenomena. A teacher orients learners in the general direction by helping them create their own models and theories through a constructed activity (Mestre, 1994).

How Do We Connect Research Knowledge to Effective Practices in Classrooms?

From the many research articles and conference presentations, it is evident that there is an abundance of information about improving students' opportunity to learn. However, currently, there is a **disconnection** between research knowledge on improving academic achievement through addressing opportunity to learn and the implementation of this knowledge in classrooms. Given the existence of extensive research information, these three questions remain critical: (1) Why are teacher educators and classroom teachers, still not producing higher academic

achievement among poor and minority students? (2) Is the research information reaching the people who need it most? and (3) If educators received the information, why don't they use it?

1. Teacher education makes a difference in producing the environment conducive for learning.

A contrastive research study was conducted in South Africa of preschool teachers who completed three years of teacher training versus teachers with less training to determine if the training had any impact on student-teacher interactions and room and yard environments. The findings indicated that training did have a positive impact. Some may ask, "What is so important about that finding?" The answer is nothing new was discovered; however, this research reconfirmed that

training or teacher education does influence how teachers behave in their classrooms (Stevens, 1995).

2. Teacher collaboration brings support for teachers to try new approaches.

In their research, Stevenson and Stigler (1992) found that Japanese elementary teachers during the school day spent much more time in collaboration and discussion about teaching practices and student outcomes. Through these collaborative activities, they tried new teaching strategies and discussed their successes and failures. They solicited suggestions from their colleagues about how to improve. Then, they tried these strategies again. "Practice makes perfect" was viewed as a positive strategy and was not believed to be a demonstration of being an ineffective or a poor teacher.

By contrast, in the United States, teachers have little time allocated during the school day for collaboration --- sharing information about effective teaching practices and other related information. They work in isolation and thus receive no feedback about what it is that they do that is good or poor. They view that being observed while teaching is a teacher accountability practice. They do not view being observed as a positive means to gain information to improve their teaching practices.

3. Teachers in communities of professionals sustain change in classrooms.

McLaughlin and Talbert (1993) after observing and interviewing secondary school teachers in several secondary schools over several years, began to see real differences in students' academic achievement in schools or subject matter departments with teachers who were in "communities of professionals" than those schools with teachers who continued the practice of teaching in isolation. McLaughlin and Talbert (1993) found that those teachers who continued with traditional teaching practices (e.g., teacher dominates, transmission teaching with more worksheets and tests, emphasis on traditional fact-based curriculum) saw behavioral and achievement problems in today's classrooms as primarily students' problems. Thus, teachers with these viewpoints who have to deal with students in the 1990s become cynical, frustrated and burned out and so do their students. Other teachers who lowered their expectations for 1990s students often water down the curriculum and both the teachers and the students become bored and disengaged from teaching and learning.

In contrast to the enforcer teachers and the low expectations teachers, there were those teachers whose teaching could be described as "teaching for understanding". However, if these teachers attempted to change while working in isolation, they too became frustrated and discouraged. Those teachers who effectively adapted their practices to "teaching for understanding" had one thing in common: they belonged to an active professional community which encouraged and enabled them to successfully transform their teaching.

4. Teaching and learning includes teachers who are learning.

So often when we use the phrase, teaching and learning, it is in the very simple and straight forward context of the teacher teaching and students learning. An enlarged the context for this phrase would be: teachers learning more effective teaching practices including effective classroom management and teachers using quality teaching practices in their classrooms effect students' learning and becoming academic achievers.

Teaching and learning in its enlarged context relates strongly to the current problem of too many urban students having low academic achievement, particularly poor and minority students. We must recognize that low academic achievement does not rest solely with students

although they are contributors to this negative outcome. Teacher preparation, preservice and inservice training, is the critical change process in improving academic achievement. A major contribution to the problem is the placement of the least prepared teachers with the students who have the greatest needs.

The new science content standards advocate new approaches to teaching and learning and they conflict with old teaching practices which were based upon traditional beliefs. For example, the old approach advocated covering many science topics while the new standard advocates studying a few fundamental science concepts. Cross (1990) noted that many teachers teach the way they were taught, emulating the teachers they observed as students These teachers have internalized these old practices and they are deeply attached to attitudes and beliefs about teaching. Researchers are suggesting that one of the principal means to shift teachers' beliefs and attitudes is through teacher training and professionalization.

Kennedy (1990) found that the quality of classroom practice is intimately tied to teacher education. Those teachers who were taught by mediocre and incompetent teachers will then spawn more mediocrity and incompetence in their classrooms. To disengage teachers from this cycle of mediocrity and incompetence, teacher education based upon education research provides teachers with knowledge of the conditions or variables that will promote quality teaching.

Preservice Education

There needs to be a serious consideration of what we require prospective and current teachers to know and understand. We need to know what prospective and current teachers believe about students, particularly students from diverse populations. We need to know if teachers are sensitively skilled in addressing the needs of diverse students. Darling-Hammond (1990) reminds us that teacher professionalism starts with the proposition that knowledge must inform practice. Its major goal is to ensure that all individuals permitted to practice are adequately prepared. In relation to the quality of teachers, Rottenberg and Berliner (1990) tell us that novice teachers without full preparation are less sensitive to students, less able to plan and redirect instruction to meet students' needs (and less aware of the need to do so), and less skilled in implementing instruction. For example, when novice teachers were asked what would they do

if their students did not learn what was taught, a common response was "to do it again."

To be adequately prepared, Darling-Hammond (1990) advocates that teacher preservice education requires its students to take the following courses:

1. Cognitive psychology, so they understand how people learn.
2. Developmental psychology, so that they understand when children are ready to learn particular things in particular ways.
3. Learning theory and pedagogy, so that they can teach in developmentally and cognitively appropriately ways.
4. Professional ethics, so that they can manage schools' competing agendas in ways that keep the best interests of students in the forefront of their actions.

Inservice Education

Kennedy (1990) advises us that the structure and format for teacher inservice education must change if teachers are to change. She informs us that the traditional strategy of inservice teacher education continues to be a popular one for improving the quality of classroom teaching practices, although most current efforts at inservice teacher education fall remarkably short of having any real impact because:

1. Most workshops are not full-blown programs but instead are brief workshops (workshops are limited to one or two per year from one-half day to a two-day session). With teachers' deep commitments to their current practices, such brief exposure to new ideas will not substantially alter classroom practices;
2. The content of these workshops changes from one to the next (e.g., assertive discipline to higher order thinking skills to time on task), so that teachers receive inconsistent messages regarding what counts as good practice and no assistance in rectifying philosophical discrepancies among the different ideas.
3. Very few inservice programs provide follow up assistance in the classroom to help teachers implement the ideas they have learned. Consequently teachers are left with only the general idea and with no specific means for implementing the ideas.

Discussion

Science standards are important to the process of science education reform. By having a standard that calls for the inclusion of all students to learn core science content means that there are higher expectations for all. That is good and fair. However, having science standards cannot be a one-way street with the sole focus on what we expect students to learn (e.g., content standard and student performance standards). Science standards should also encompass our expectations for teachers ---teacher preservice and inservice education to upgrade content information and teaching skills. Also, there should be standards that impact and motivate the school leadership to revise the structure and organization and environment for teaching science. Opportunity to learn information and its use can be the investigative/accountability template for producing effective science education reform.

The report of what is happening in classrooms is not enough. Educators must use the information provided by education research. When we connect research information, we can change classroom practices. Unfortunately, present conditions for teachers to obtain knowledge are quite difficult. We must change this because students in urban school classrooms will have a much better chance to improve their academic achievement in science, and other core subjects, if their teachers improve these students' opportunity to learn. Knowledge of opportunity to learn acquired through preservice and inservice education seems to be a challenge that can be met when those of us who are responsible for pre-service and inservice education of teachers are also willing to change. When this happens, there will be a greater possibility of poor and minority students achieving at higher levels in science and other subject areas. It is quite probable that students' higher academic achievement accompanied with the acquisition of problem solving skills learned and applied in science courses will better ensure their success as adults in the 21st Century.

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The Mid-Atlantic Laboratory for Student Success

The Mid-Atlantic Laboratory for Student Success (LSS) is one of ten regional educational laboratories in the country funded by the U.S. Department of Education to revitalize and reform educational practices in the service of educational success of all children and youth in this country.

The mission of the Mid-Atlantic Laboratory for Student Success (LSS) is to play a pivotal role in the educational reform process throughout the mid-Atlantic region to significantly affect the region's capacity for bringing about lasting improvements in the learning of its increasingly diverse student population.

The LSS will facilitate the transformation of research-based knowledge into useful tools that can be readily integrated into the educational reform process both regionally and nationally. Likewise, the work of the LSS will be continously refined based on feedback from the field on what is working and what is needed.

The ultimate goal of the LSS is a connected system of schools, parents, community agencies, professional groups, and institutions of higher education that not only comes "up to scale" for the entire region but also is linked with a high-tech national system for information exchange. In particular, the aim is to bring researchers and research-based knowledge into synergistic and coherent coordination with efforts for educational improvement led by field-based professionals.

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